Executive Summary

BACKGROUND

The use of treated municipal wastewater effluent for irrigated agriculture offers an op-portunity to conserve water resources. Water reclamation can also provide an alternative to disposal in areas where surface waters have a limited capacity to assimilate the contaminants, such as the nitrogen and phosphorus, that remain in most treated wastewater effluent discharges. The sludge that results from municipal wastewater treatment processes contains organic matter and nutrients that, when properly treated and applied to farmland, can improve the physical properties and agricultural productivity of soils, and its agricultural use provides an alternative to disposal options, such as incineration, or landfilling.

Land application of municipal wastewater and sludge has been practiced for its beneficial effects and for disposal purposes since the advent of modern wastewater management about 150 years ago. Not surprisingly, public response to the practice has been mixed. Raw municipal wastewater contains human pathogens and toxic chemicals. With continuing advances in waste-water treatment technology and increasingly stringent wastewater discharge requirements, most treated wastewater effluents produced by public treatment authorities in the United States are now of consistent, high quality. When treated to acceptable levels or by appropriate processes to meet state reuse requirements, the effluent is referred to as "reclaimed water." Sewage sludge can also be treated to levels that allow it to be reused. With the increased interest in reclaimed water and the promotion of agricultural use for treated sludge, there has been increased public scrutiny of the potential health and environmental consequences of these reuse practices. Farmers and the food industry have expressed their concerns that such practices—especially the agricultural use of sludge—may affect the safety of food products and the sustainability of agricultural land, and may carry potential economic and liability risks.

Reclaimed water in the United States contributes a very small amount (probably much less than one percent) of water to agricultural irrigation, mainly because the extent of the practice is limited both by regional demands and the proximity of suitable agricultural land to many municipal wastewater treatment plants. Most reclaimed water goes towards various nonpotable urban uses such as irrigating public landscapes (parks, highway medians, lawns, etc.), air-conditioning and cooling, industrial processing, toilet-flushing, vehicle-washing, and construction. Irrigation of residential lawns and/or gardens with reclaimed water is becoming increasingly popular where dual plumbing systems to facilitate water reuse have been installed; however, this report concentrates on agricultural uses of reclaimed water, and not residential use.

Sewage sludge (or simply, "sludge") is an inevitable end product of modern wastewater treatment. Many of the organic solids, toxic organic chemicals, and inorganic chemicals (trace elements) are removed from the treated wastewater and concentrated in the sludge. An estimated 5.3 million metric tons per year dry weight of sludge are currently produced in the United States from publicly owned treatment plants. This amount will surely increase as a larger population is served by sewers and as higher levels of wastewater treatment are introduced.

Sludge disposal has always represented a substantial portion of the cost of wastewater management. Over the past 20 years, restrictions have been placed on certain sludge disposal practices (e.g., ocean dumping and landfill disposal), causing public wastewater treatment utilities to view the agricultural use of sludge as an increasingly cost-effective alternative. Cur-rently, 36 percent of sludge is applied to the land for several beneficial purposes including agriculture, turfgrass production, and reclamation of surface mining areas; 38 percent is land-filled; 16 percent is incinerated; and the remainder is surface disposed by other means.

The Midwest has a long history of using treated sludge on cropland. Much of the crop-land that receives sludge is used to grow hay, corn, and small grains for cattle feed, and public acceptance generally has been favorable. In Madison, Wisconsin, for example, the demand for sludge as a soil amendment exceeds the local supply. With ocean disposal of sludge no longer allowed, New York City and Boston—among other coastal cities—ship much of their sludge to other parts of the country. A portion of the sludge produced in the Los Angeles Basin is trans-ported to a large farm near Yuma, Arizona.

If all the municipal sludge produced in the United States were to be agriculturally ap-plied at agronomic rates, it would only be able to satisfy the nitrogen needs of about 1.6 percent of the nation's 1,250 million hectares (309 million acres) of cropland. About one quarter of this cropland is used to grow food for human consumption, of which 2 percent grows produce crops that can be consumed fresh. Thus, in a national context, the amount of food crops produced on fields receiving sludge would remain very small. Nevertheless, the local availability of agricultural land, combined with other regional and local concerns, is an important factor in sludge management decisions. While many western and midwestern states have ample ag-ricultural land relative to the amount of sludge produced, land is less available in other regions. In New Jersey, for example, over half the state's cropland would be needed to receive sludge application to avoid other forms of disposal or out-of-state disposal. Rhode Island would need essentially all of its cropland to satisfy its sludge disposal needs through in-state agricultural use. The level of public acceptance for agricultural use of sludge varies considerably. Nuisance (e.g. odors and traffic), environmental, and safety issues are legitimate concerns that must be addressed by regulatory policy and management programs.

In February 1993, the U.S. Environmental Protection Agency (EPA) promulgated *Standards for the Use or Disposal of Sewage Sludge* (Code of Federal Regulations Title 40, Parts 257, 403, and 503, and hereafter referred to as the "Part 503 Sludge Rule"). This rule builds on a number of federal and state regulations that aim to reduce pollutants entering the municipal waste stream through source controls and industrial pretreatment programs that have reduced the levels of contaminants in the sludge as well as in the final effluent. The Part 503 Sludge Rule defines acceptable management practices and provides specific numerical limits for selected chemical pollutants and pathogens applicable to land application of sewage sludge. In this context, sewage sludge—traditionally regarded by many groups as an urban waste requiring careful disposal—is now viewed by the wastewater treatment industry, the regulatory agencies, and participating farmers as a beneficial soil amendment.

EPA believed that both water reclamation and sludge beneficial use programs could be-nefit from an independent assessment of the public health and environmental concerns that have been raised by the food processors concerning land application of treated municipal wastewater and sludge. In mid-1993, at the suggestion of EPA, and with support of a number of co-sponsors, the National Research Council (NRC) undertook this study to examine the use of treated municipal wastewater and sludge in the production of crops for human consumption. The study reviews the current state of the practice, public health concerns, existing guidelines and regulations, and implementation issues. The report makes a number of recommendations resulting from the study that are summarized below.

CONCLUSIONS AND RECOMMENDATIONS

Irrigation of food crops with treated municipal wastewater has been effectively and safely practiced in the United States on a limited scale. The public has generally accepted the concept of wastewater irrigation as part of larger and more comprehensive water conservation programs to reclaim wastewater for a variety of nonpotable uses. Where reclaimed water has been used for food crop production, the state standards for wastewater treatment and reuse, along with site restrictions and generally good system reliability, have insured that food crops thus produced do not present a greater risk to the consumer than do crops irrigated from conventional sources.

The beneficial reuse of municipal sludge has been less widely accepted. Federal reg-ulations are designed to assure that sludge application for the production of food crops does not pose a significant risk from the consumption of foods thus produced. However, the parties affected by these reuse programs—local communities, crop growers, food processors, and the consumer—remain concerned about the potential for exposure to contaminants, nuisance prob-lems, liability, and adequacy of program management and oversight. Sludge management pro-grams based on agricultural sludge use can involve many potentially responsible parties, and can cross agency, state, and federal jurisdictional boundaries. Therefore, municipalities, public utilities, crop growers, and food processors must be able to provide well-managed and reliable programs that address, and are open to, community, business, health, agronomic, and environ-mental concerns.

Adequacy of Existing Regulations for Pathogens in Reclaimed Water and Sludge

Municipal wastewater contains a variety of pathogenic (infectious) agents. When reclaim-ed water or sludge is used on fields producing food crops, the public health must be protected. This can be achieved by proper wastewater or sludge treatment and site management that reliably reduces the pathogens to acceptable levels.

There are no federal regulations directly governing the use of municipal wastewater to irrigate crops. However, EPA provided guidelines for reclaimed water quality and its use for crop irrigation in its 1992 *Guidelines for Water Reuse*. There are currently 19 states that regulate the practice by setting criteria for reclaimed effluent quality, such as microbiological limits or process standards; crop restrictions; or by waiting periods for human or grazing animal access or before crop harvest. State regulations vary; some require very high-quality effluents to reduce the concentration of pathogens to levels acceptable for human contact prior to irriga-tion. Others depend on the use of crop restrictions and site limitations, thus allowing required time for pathogens to decrease to acceptable levels. In general, modern wastewater treatment procedures incorporate monitoring and technical redundancies that provide system reliability and protection against exposure to pathogens.

The strategy for regulating pathogens in the agricultural use of sludge is similar. The Part 503 Sludge Rule requires the use of either Class A pathogen criteria, in which the sludge is considered to be safe for direct public contact, or Class B pathogen criteria, in which site and crop restrictions are required.

Class A (safe for public contact) microbial standards or process standards for sludge appear to be adequate for public health protection. The Part 503 Sludge Rule allows for direct testing of pathogens (bacteria, viruses, and helminths), and the use of salmonella or fecal coliform testing as alternative indicators to determine Class A sludge quality. The prescribed methods for the testing of salmonella are of questionable sensitivity. Until such time as more precise methods are developed and accepted, the present test for salmonella should not be used as a substitute for the fecal coliform test; rather, it should be run in concert with that test or in situations in which the fecal coliform results are in question, such as may happen under some operating conditions. The salmonella test is less precise because of the relatively low numbers of salmonella present compared to fecal coliform.

Restrictions on the use of Class B sludge require allowing a suitable length of time for die-off of helminth ova, which can be transmitted to humans via improperly cooked, con-taminated meat. The control of helminth parasites is achieved largely through public health education (e.g., the need for thorough cooking of meat) and government meat inspection, as well as controls over applications of wastewater and sludge to land. Based on a review of U.S. studies, the Part 503 Sludge Rule requires a 30-day waiting period before cattle can graze on Class B sludge-amended fields. A recent investigation in Denmark indicates that the beef tapeworm (*Taenia* sp.), one of the helminth group, may survive in sludge-treated fields for up to one year. Although the evidence comes from a single study, there is reason to believe that the length of the waiting period for grazing following sludge application to pastures needs to be re-examined.

There have been no reported outbreaks of infectious disease associated with a popula-tion's exposure—either directly or through food consumption pathways—to adequately treated and properly distributed reclaimed water or sludge applied to agricultural land. Reports and available epidemiological evidence from other countries indicate that agricultural reuse of *un-treated* wastewater can result in infectious disease transmission. The limited number of epidemiological studies that have been conducted in the United States on wastewater treatment plant workers or populations exposed to various reclaimed water or treated sludge via land application projects indicate that exposure to these materials is not a significant risk factor. However, the value of prospective epidemiological studies on this topic is limited because of a number of factors, including a low illness rate—if any—resulting from the reuse practice, in-sufficient sensitivity of current epidemiological techniques to detect low-level disease trans-mission, population mobility, and difficulty in assessing actual levels of exposure.

Infectious diseases of the types potentially associated with municipal wastewater are under-reported and exposures are scattered, so that some effects may well go unrecorded. From a public health point of view, the major microbiological considerations for evaluating any reuse management scheme are the ability to effectively monitor treatment efficacy and the reliability of the process used to reduce pathogens to acceptable levels.

Recommendations

· Until a more sensitive method for the detection of salmonella in sludge is developed, the present test should be used for support docu-mentation, but not be substituted for the fecal coliform test in evaluating sludge as Class A.

· EPA should continue to develop and evaluate effective ways to monitor for specific pathogens in sewage sludge.

· EPA should re-evaluate the adequacy of the 30-day waiting period following the application of Class B sludge to pastures used for grazing ani-mals.

Adequacy of Existing Regulations for Harmful Chemicals in Reclaimed Water and Treated Municipal Sludge

Reclaimed Water

States that regulate the use of reclaimed water for crop irrigation have focused on its microbiological quality and have not typically set human health criteria for harmful inorganic (trace elements) and organic chemicals in the reclaimed water. Instead, reliance is placed on the wastewater treatment processes to reduce these constituents to acceptable levels in reclaimed water.

Potentially harmful trace elements, such as arsenic, cadmium, cobalt, copper, lead, mer-cury, molybdenum, nickel, selenium, and zinc are found in treated municipal wastewater eff-luents. In 1973, the National Academy of Sciences issued a report on water quality criteria that recommended limits on the concentration of trace elements in irrigation water with regard to their effects on crop production. These agricultural irrigation guidelines have been generally accepted by EPA and others. Reclaimed water that has received a minimum of secondary treatment normally falls within these guidelines. While wastewater treatment processes typically used in the United States are not usually intended to specifically remove trace elements from the waste stream, most of the trace elements are only sparingly soluble and tend to become concentrated in the residual solids or sludge fraction. Chemical production and use bans, industrial pre-treatment programs, and municipal wastewater treatment have been effective in reducing the levels of toxic constituents in wastewater effluents to acceptable levels.

Wastewater treatment processes also remove many toxic organic chemicals in the wastewater stream through volatilization and degradation. Those that remain in the final effluent may volatilize or decompose when reclaimed water is added to soil. Consequently, only neg-ligible quantities of toxic organic chemicals from municipal wastewater systems—those relatively resistant to decomposition—will persist in soils for an extended period. In general, toxic organic chemicals, especially those that persist in the soil, are not taken up by plants when the water application rates are commensurate with crop needs. Therefore, the immediate or long-term threat from organic chemicals to humans consuming food crops irrigated with reclaimed water is negligible.

Treated Municipal Sludge

Potentially harmful chemicals (largely, trace elements and persistent organics) become concentrated in the sludge during the wastewater treatment process. Following repeated land applications, trace elements, except for boron, will accumulate in the soil to, or slightly below, the depth of sludge incorporation. The persistent organic chemicals degrade over time in soils. Degradation rates are dependent on the chemical in question and on soil properties.

The Part 503 Sludge Rule for the agricultural use of sludge sets criteria for concentrations of 10 trace elements in sludge; arsenic, cadmium, chromium[1], copper, lead, mercury, molyb-denum[1], nickel, selenium[1], and zinc. The rule is based on a risk-assessment approach that considered the effects of these trace elements and organic chemicals of concern on crop pro-duction, human and animal health, and environmental quality. Except for cadmium, these trace elements are not ordinarily taken up by crop plants in amounts harmful to human consumers. EPA regulations for cadmium in sludge are sufficiently stringent to prevent its accumulation in plants at levels that are harmful to consumers.

In deriving pollutant loading rates for land application of sewage sludge, EPA considered 14 transport pathways and, in all cases, selected the most stringent value as the limit for each pollutant. For the 10 regulated inorganic pollutants, the most stringent loading rates were derived from pathways that involved a child directly ingesting sludge or from pathways involving effects on crops. This resulted in significantly lower pollutant limits than would have been the case had they been set by human food-chain pathways involving human consumption of food crops, meat or dairy products. Therefore, when sludges are applied to land according to the Part 503 Sludge Rule, there is a built-in safety factor that protects against human exposure to chemical contaminants via human food-chain pathways.

Available evidence indicates that most trace organic chemicals present in sludge are either not taken up or are taken up in very low amounts by crops after sludge is applied to land. The wastewater treatment process removes most of these organic chemicals, and further reduction occurs when sludge is processed and after it is added to soil. Consequently, only negligible quantities of toxic organic chemicals from municipal wastewater systems will persist in soils for an extended period. Recent studies suggest that plant tissues may absorb volatile toxic organic chemicals from the vapor phase of volatile compounds; however, the aeration that occurs during treatment of wastewater and during many sludge treatment processes removes most of the volatile organic chemicals at the treatment plant.

This study revealed some inconsistencies in EPA's approach to risk assessment and its technical interpretation for development of the Part 503 Sludge Rule, although the inconsistencies do not affect food safety. To improve the overall integrity of the regulation, EPA should address the exemption of organic pollutants and the marketing of sludge products to the public.

Exempting Organic Pollutants EPA chose not to regulate organic pollutants in the Part 503 Sludge Rule because all priority organic pollutants that were considered fell into at least one of the three exemption categories: (1) the pollutant has been banned in the United States and is no longer manufactured, (2) the pollutant was detected by EPA in less than 5 percent of the sludge from

[1]Selected criteria have since been rescinded or are under review by EPA.

wastewater treatment plants sampled in a national sewage sludge survey, or (3) the concentration of the pollutant was low enough that it would not exceed the risk-based loading rates. Nevertheless, PCBs and aldrin/dieldrin occurred at higher than 5 percent detection frequency, and the concentrations of PCBs, hexachlorobenzene, benzo(a)pyrene, and N-nitro-sodimethylamine would result in pollutant loadings exceeding EPA's risk-based limits in a small percentage of sludges. Some of these have been banned but persist in the environment. While the probability that the compounds would affect human-consumed crops is very low, the potential for human exposure to these chemicals through other pathways as defined in the Part 503 Rule should be re-evaluated.

The basis for exempting organic chemical pollutants rests, in part, on the integrity of the 1990 National Sewage Sludge Survey (NSSS)—the data base used by EPA to determine concentrations of pollutants in sludge. The survey has been criticized because sludge samples analyzed from the treatment plants varied in their water content which caused inconsistencies when deriving standardized detection limits of chemicals. As a result, estimates of frequencies and concentrations for certain organic chemicals may not be reliable. A credible data set of toxic chemical concentrations in sewage sludge based on a nationwide survey is essential. To update its information on sludge quality, EPA plans to repeat the survey in the near future. In conducting a second NSSS, EPA should strive to improve the integrity of the data by using more consistent sampling and data-reporting methods.

Recommendation

- **A more comprehensive and consistent survey of municipal waste-water treatment plants is needed to show whether or not toxic organic com-pounds are present in sludges at concentrations too low to pose a risk to human and animal health and to the environment. In conducting a second NSSS, EPA should strive to improve the integrity of the data by using more consistent sampling and data-reporting methods. The EPA should not exclude chemicals from regulatory consideration based solely on whether or not those chemicals have been banned from manufacture in the United States (e.g., PCBs) since they are still found in sludges from many wastewater treatment plants.**

Marketing Sludge Products to the Public In addition to its use on agricultural land, sludge can be marketed and distributed to the public for home gardening and landscaping purposes. EPA has used the term "Exceptional Quality" (EQ) to refer to sludge that meets specified low pollutant and pathogen limits and that has been treated to reduce the level of degradable compounds that attract vectors. EQ sludge is a product that required no further regulation. EPA allows sludge that is sold or given away to the public to exceed the EQ chemical pollutant concentrations with the stipulation that prescribed application limits not be exceeded. However, there is little assurance that the home gardener or landscaper will either be aware of or be able to follow these requirements, nor is there a method for tracking the disposition of sludge marketed to the public. Allowing sludge with less than the highest quality chemical pollutant limits to be used by the public opens the door to exceeding regulatory limits, and thereby undermines the intent of Part 503 and public confidence in the law.

Recommendation

· **The Part 503 Sludge Rule should be amended to more fully assure that only sludge of exceptional quality, in terms of both pathogen and chem-ical limits, is marketed to the general public so that further regulation and management beyond the point of sale or give-away would not be necessary.**

Soil, Crop, and Ground Water Effects

Reclaimed Water

Guidelines for the chemical quality of water used in agricultural irrigation have been generally accepted since recommended limits were set by a National Academy of Sciences report in 1973. These guidelines concern potential toxicity to plants or to crop productivity. Where industrial pretreatment programs are effectively implemented (or where industrial input is low), reclaimed water that has received a minimum of secondary treatment will normally meet these recommended limits for irrigation water quality.

While the plant nutrients in treated effluents are generally considered a supplemental fer-tilizer source, the application rates are not easily controlled compared to commercial fertilizer operations. Wastewater irrigation could exceed the nitrogen and phosphorus requirements of many crops during the growing season. Further, plants require nutrients and water at different stages in the growth cycle and the timing of irrigation may not correspond to times when plant nutrients are needed. Wastewater applications at times when the plant nutrient needs are low can lead to excessive vegetative growth, can affect crop maturity, and can cause leaching of nitrate nitrogen and possible nitrate contamination of ground water.

The application of wastewater effluents to soils may pose some risk of ground water contamination by viruses and bacteria; however, that risk can be minimized by adequate disinfection of reclaimed wastewater and by slow infiltration rates.

Recommendation

· **Those who irrigate crops with treated municipal wastewater should be aware of the concentration of nutrients (nitrogen and phosphorus) in the reclaimed water and should adjust fertilizer practices accordingly in order to avoid undesirable vegetative growth or potential contamination of ground water.**

Treated Municipal Sludge

Municipal sewage sludge is a source of nitrogen and phosphorus in crop production. The addition of organic matter through successive sludge applications improves the physical prop-erties and productivity of soils. When used at agronomic rates for nitrogen and phosphorus, sewage sludge can usually satisfy crop requirements for many other nutrients as well, with the possible exception of potassium. EPA's Part 503 Sludge Rule specifies the annual and cum-ulative loadings of trace elements in sludge-amended soils, and, based on currently available information, these limits are adequate to protect against phytotoxicity and to prevent the ac-cumulation of these elements in crops at levels harmful to consumers.

Because repeated sewage sludge applications lead to accumulations of trace elements in soil, concern has been expressed over possible adverse effects associated with the use of sludge on soils that are acidic or may become acidic. However, as long as agricultural use of treated sludge is in keeping with current regulations and acid soils are agronomically managed, no adverse effects are anticipated. The Part 503 Sludge Rule is based on approximately 20 years of research and experience in applying sewage sludge to cropland. While this has provided an adequate knowledge base for developing the regulations, continued monitoring of trace elements in soils over longer time periods is desirable.

As in all farm operations, proper management is needed to avoid the buildup of nitrates. Typically, sludges comprise approximately 1 to 6 percent organic and inorganic nitrogen on a dry weight basis. The soluble inorganic forms are immediately available to plants, but the or-ganic forms must first be mineralized to plant-available forms. For sludge to be efficiently used as a source of available nitrogen, the mineralization of organic nitrogen must be taken into account to avoid overfertilization and potential leaching of excess nitrate-nitrogen into ground water.

Most sludges supply more than enough phosphorus to satisfy crop needs when applied as a source of nitrogen. In certain soils, available phosphorus may be excessive, particularly where animal manure is plentiful and where impacts to surface water quality are of concern. In these situations, soil phosphorus levels should be monitored and sludge application rates be adjusted to correspond to crop phosphorus rather than nitrogen needs.

Heavy metals are not mobile in soils, and their transport to ground water as a result of sewage sludge application at agronomic rates is unlikely. Likewise, toxic organic compounds in sludge are not likely to contaminate ground water because their concentrations are low, because they are volatilized or biodegraded in soils, or because they are strongly sorbed to soil particles. Because of predictable pathogen die-off and because of the immobilization of micro-organisms on sludge and soil particles, the risk of transporting viruses, bacteria, and protozoa to ground water due to sludge application is negligible as long as sludge is properly treated and applied to or incorporated into unsaturated soils. As with all agricultural soil amendments, sludge use must be managed properly to avoid contamination of surface or ground waters.

Recommendations

- **When determining sludge and fertilizer application rates, an anal-ysis of the rates of organic nitrogen mineralization should be performed in order to avoid buildup of excess nitrate-nitrogen. Nitrate-nitrogen that is not taken up by plants may contribute to excess fertilization and leaching. Where excess phosphorus is of concern, soil phosphorus levels should be monitored and sludge application rates should be adjusted to correspond to crop phosphorus rather than nitrogen needs.**

- **As more croplands are treated with municipal sludges and reach their regulatory limit of chemical pollutant loading from sludge applications, additional information will be needed to assess potential, long-term impacts of sludge on ground water quality and on the sustainability of soils for crop production.**

Economic, Legal, and Institutional Issues

In addition to human health and environmental concerns, there are other barriers to in-creased acceptance of treated municipal wastewater and/or sludge application in the production of food crops. In general, however, barriers to acceptance apply more to agricultural use of sludge than to crop irrigation with reclaimed water. These potential barriers include lack of economic incentives for the farmer, lack of public confidence in the adequacy of regulatory systems to ensure compliance, agribusiness concerns with potential liability or economic losses due to decreases in both land value and crop value, and public concerns over nuisance factors.

Economic Considerations

There are negligible economic incentives for food processors to accept crops produced with reclaimed water or treated sludge. Benefits in terms of lower raw food costs are likely to be minimal, potential risks could lead to liability, and the negative public perception of food crops produced using these materials could have a detrimental impact on consumer demand.

Even though the value of the water and nutrients represents only a small percentage of total farm production costs, there are many cases of clear economic incentives for society as a whole as well as for municipal wastewater treatment plants to pursue cropland reuse options. In water-scarce areas, reclaimed water should have value comparable to that of irrigation water from conventional sources. Where alternative irrigation water is cheaply available, there are only limited incentives for farmers to apply reclaimed water. Limited economic incentives exist for farmers to use sludge because fertilizer is relatively inexpensive and sludge use may entail additional management concerns. It may be appropriate to pay the farmer where the regulatory compliance costs associated with using reclaimed water or treated sludge exceed their beneficial use values. However, payments should not encourage excessive application rates that would interfere with the proper agronomic use of these materials.

Recommendation

- **Any payment program designed to promote agricultural use of treated effluents or treated sludge should be carefully structured to avoid the creation of incentives to apply reclaimed water or sludge at rates in excess of agronomic**

rates, and to avoid undermining farm management practices need-ed to protect public and occupational health and the environment.

Public Perception and Liability

The public is concerned about the health and environmental risks associated with bene-ficial land application of sludge, particularly in areas where land application has only recently been implemented or considered. Some of this concern is not scientifically supportable, and should be addressed with education programs and early public involvement in the design of land-application programs. In addition, private-sector forces can deter violations of the law and mis-management by the various parties involved in reuse programs. Private-sector forces include common-law liability, market forces, and voluntary self-regulation such as codes of conduct, worker training and certification, and audits. Although insurance coverage and indemnification contracts for the farmer are useful means of self-regulation and protection against certain kinds of economic harm, it is unlikely that they will be sufficient to satisfy all concerns of the farmer, food processors, general public, and the affected community. Thus, public concerns about real or perceived residual risks create business risks and militate against agricultural use of sludge and reclaimed water despite the federal or state regulatory safeguards. Proponents of cropland application of sludge and wastewater must, therefore, address such public concerns if they are to achieve their goals.

Recommendations

- **States and municipalities that wish to implement a beneficial-use program need to address public concerns and provide assurances that the new uses of sludge and wastewater do not endanger health or the environ-ment in application areas. The public and local officials should be involved in the decision-making process at an early stage.**
- **The operators of municipal wastewater treatment facilities and the parties using sludge and wastewater should implement visible, stringent management and self-regulation measures, including monitoring and reliable reporting by farmers, and should support vigilant enforcement of appropriate regulations by local or state agencies. Implementation of these measures will be credible means of preventing nuisance risks and harm to people, property, and highly valued nearby resources.**
- **The municipal utility should carry out demonstration programs for public education, and to verify the effectiveness of management and self-regulatory systems. In addition, the utility should be prepared to indemnify farmers against potential liabilities when farmers' financing by banks or oth-er lenders may hinge on this assurance.**

Other Regulations and Institutional Controls

From a regulatory perspective, it is important to remember that EPA's Part 503 Sludge Rule augments a wide array of existing institutional programs and controls over the disposition of municipal wastewater and sludge. For example, federal and state regulations govern the handling and treatment of toxic waste and the protection of surface and ground waters. These regulatory mandates appear adequate to manage most of the risks associated with land app-lication, but they must be funded and implemented to be meaningful safeguards.

Sludges that do not meet beneficial use criteria standards as defined by the Part 503 Sludge Rule must be disposed of according to federal and state regulations as applicable. Both the general public and state and local regulators should be aware that the Part 503 Sludge Rule is not the only control over agricultural use of sewage sludge.

Recommendation

- **Management of sludge for beneficial use should be more visibly linked to existing regulations governing its disposal. Program credibility may be improved and public concern reduced if federal, state, and municipal regulators clearly assign authority to local governments for responding to any reports of adverse consequences related to beneficial use of sludge, such as ground water contamination, odor, attraction of vermin, or illnesses. The public should be aware that state and local units of government have the necessary regulatory authority to take corrective actions against parties who have violated rules and guidance.**

CONCLUDING REMARKS

In summary, society produces large volumes of treated municipal wastewater and sewage sludge that must be either disposed of or reused. While no disposal or reuse option can guar-antee complete safety, the use of these materials in the production of crops for human consumption, when practiced in accordance with existing federal guidelines and regulations, presents negligible risk to the consumer, to crop production, and to the environment. Current technology to remove pollutants from wastewater, coupled with existing regulations and guidelines governing the use of reclaimed wastewater and sludge in crop production, are adequate to protect human health and the environment. Established numerical limits on con-centration levels of pollutants added to cropland by sludge are adequate to assure the safety of crops produced for human consumption. In addition to health and environmental concerns, institutional barriers such as public confidence in the adequacy of the regulatory system and concerns over liability, property values, and nuisance factors will play a major role in the acceptance of treated municipal wastewater and sewage sludge for use in the production of food crops. In the end, these implementation issues, rather than scientific information on the health and safety risks from food consumption, may be the critical factors in determining whether reclaimed wastewater and sludge are beneficially reused on cropland.

The use of wastewater and sludge in the production of crops for human consumption presents a manageable risk. However, the implementation of regulations and guidelines is where problems are most likely to arise. Municipal wastewater treatment plants, private processors, distributors, and applicators must not only comply with all regulatory requirements and man-agement practices, they must take extra steps to demonstrate to various stakeholders (e.g., neighbors, farmers, food processors, and consumers) that such compliance is occurring. This must be done through full public participation opportunities, self-monitoring and reporting programs, and public education campaigns. This is particularly true if monitoring by state or local entities is likely to be minimal. General acceptance of sludge application for food crop production probably hinges most on the development of successfully implemented projects that meet state and federal regulations and address local public concerns.